QSO LUMINOSITIES AT λ 1 MM

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The results discussed here are based on observations at λ 1 mm of 36 optically selected quasars (Sherwood et al., 1982; in preparation) and of 24 flat spectrum radio sources with S_ν (5 GHz) $\geq$ 1 Jy (Kühr et al., 1979, 1981). H = 50 km/(s Mpc) and q_o = 0 are used.

In Figure 1 we compare the power for sources detected at $\geq 3\sigma$ in the raw data at λ 1 mm (dots) with other objects similarly detected in X-rays (crosses) (Ku et al., 1980; Zamorani et al., 1981). The millimeter and X-ray samples are based on optical and radio selection criteria. Radio selected quasars tend to have intermediate redshifts and luminosities relative to the optical samples. X-ray selected quasars have a mean redshift of only 0.42 (Margon et al., 1982). There may be low mm luminosity QSOs at high redshifts but there appear to be no high luminosity QSOs at low redshift. Nearly three-quarters of the sources (28) in

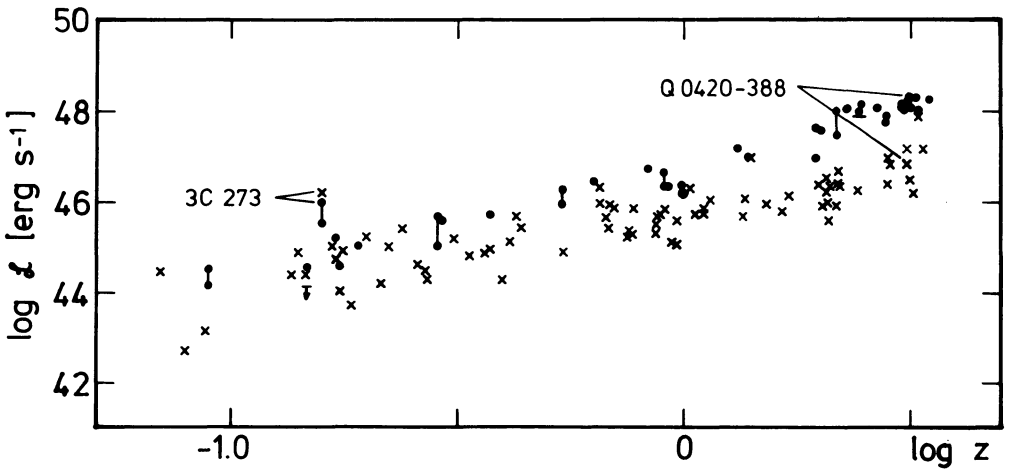

Figure 1. The power of quasars at λ 1 mm (dots) and in X-rays (crosses) as a function of redshift, z.

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this millimeter sample are more luminous than 3C 273. At high redshifts QSOs emit more power near λ 1 mm than they do at X-ray wavelengths. The difference decreases toward lower redshifts and eventually reverses, i.e., more power in X-rays than at λ 1 mm. A millimeter survey will be of great interest to see how frequently such high luminosity objects occur.

The rate of detection of quasars at λ 1 mm is a function of selection criteria and redshift. As seen in Table 1 the detection rate at the 3σ flux density level of optically selected quasars increases with red-shift while that for radio selection declines. This is also seen for the independently selected radio sample observed by Jones et al. (1981). Both radio and optical samples are flux density (apparent magnitude) limited.

Finally, the millimeter to X-ray luminosity ratio may be directly compared in Figure 2. The ratio $\mathcal{L}(300\text{ GHz})/\mathcal{L}(\text{XR})$ is nearly independent of z except for a K-term of the form

$$(1+z)^{(\alpha(\text{XR}) - \alpha(300))}$$

if $\alpha(\text{XR}) \neq \alpha(300)$. For the present data reasonable errors in the spectral indices do not explain the appearance of Figure 2. The complete lack of simultaneous observations of these sources, some of which are obviously variable at one or both frequencies, is the major source of error.

Nevertheless, for a ratio which ought to be nearly independent of z there is a remarkably good regression. Selection effects cannot be ruled out until a millimeter survey has been undertaken. The distribution may exist only among the most luminous quasars or there may be parallel sequences for quasars of lower luminosity at any epoch.

For comparison the data for four BL Lac objects having some kind of redshift estimates are represented in the figure by triangles. These

Table 1: Statistics of Detections (3σ Flux Density Level) at λ 1 mm

$z < 1.00$ (assuming all BL Lac objects have $z < 1.00$)		
20 of 30 sources:		
selection:	optical (mag)	7 of 12
	radio	13 of 18
(cf Jones et al. (1981):	radio	9 of 14)
$1 \leq z < 3.00$		
11 of 20 sources:		
selection:	optical (mag)	11 of 14
	radio	0 of 6
(cf Jones et al.:	radio	0 of 1)
$z > 3.00$		
7 of 10 sources:		
(The other three have $\geq 3\sigma$ detections in the raw data)		
(selection: optical emission line redshift)		

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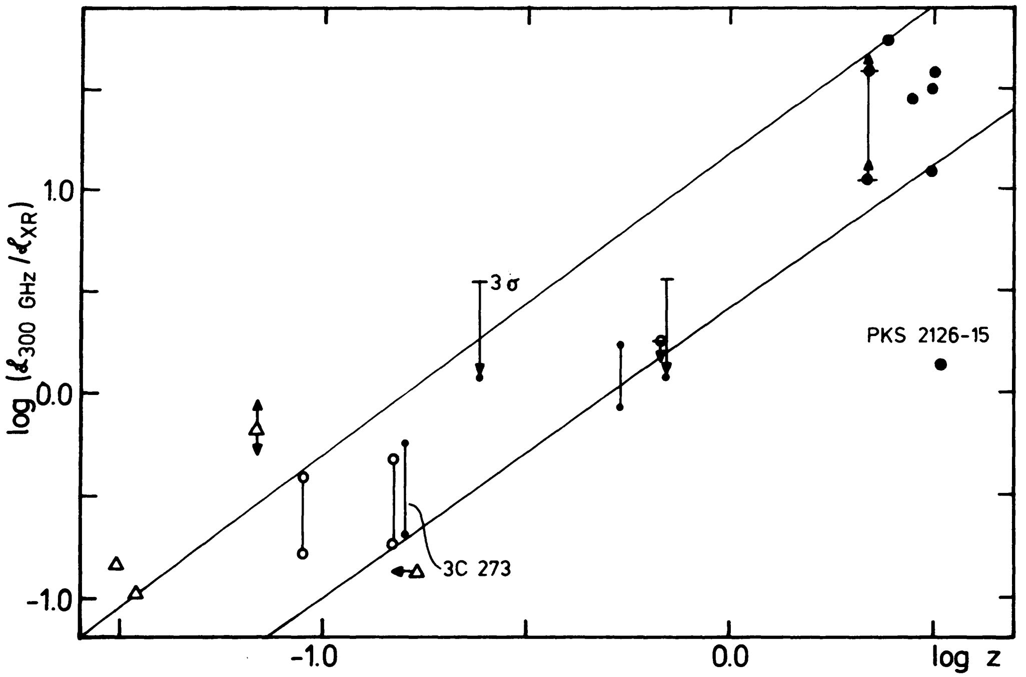

Figure 2. The ratio of millimeter to X-ray power vs. z
The large filled and open circles represent quasars selected for the presence of emission lines and UV excess respectively. The points are for radio selected quasars except the one marked by the 3σ upper limit-it represents an X-ray discovered quasar (Chanan et al., 1981) with a 1σ detection at λ 1 mm.

redshifts appear to agree with the mean relation to within a factor of ∿ 2.

Summary

1) the luminosity of quasars observed at λ 1 mm can exceed 10^{48} erg s^{-1} (H = 50 km/(s Mpc), q_0 = 0
2) at redshifts z > 0.5 the upper envelope of the millimeter luminosity distribution exceeds that of the X-ray distribution
3) a millimeter survey may lead to the detection of very large redshift quasars
4) there is a good correlation between redshift and the ratio of 1 millimeter luminosity to X-ray luminosity. There is certainly no global millimeter to X-ray luminosity ratio.

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